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The food composition of Grey Partridge chicks *Perdix perdix* in central Finland

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The purpose of this study was to investigate the composition of the diet and food selection of grey partridge chicks *Perdix perdix* in northern ranges. The study was carried out in the municipality of Tyrnävä, in central Finland (64°47′N, 25°40′E), in the middle of ca. 20 km^2 of arable land. Three grey partridge broods were followed with the aid of radio transmitters placed on the back of females. The night roosting places were located and droppings of the chicks were collected. Four droppings from every second night were analysed to investigate the diet of the chicks during their first weeks. Reference material was collected by pitfall traps and by sweep net. Chicks used a diverse assortment of invertebrates, but cicadas and beetles were most numerously eaten. When the abundance of different invertebrate taxa was taken into account, chicks preferred Delphacidae, Carabidae, larvae of Silphidae, Chrysomelidae, other Coleopteras and Aphidoidea, whereas they consumed less invertebrates than expected belonging to taxa of Diptera and Araneae. Despite the uniform selection of certain insects, the variation of food composition between broods was large. In a DCA-ordination the droppings of different broods are presented as their own subgroups, with only a few droppings overlapping. During the first three weeks the diet of the chicks was primarily composed of invertebrates. The proportion of plant material increased slightly towards the end of the study period.

1. Introduction

In the last few decades the partridge stocks have declined sharply in Finland. Back in the 1950s there were 15 000 pairs of grey partridge (Merikallio 1958), but in the 1980s the numbers were estimated to be around 3 000–6 000 pairs (Koskimies 1993). The decrease of the stocks has been observed also in other Nordic countries (Dahlgren 1987, Koskimies 1993) and, in fact, all over the distribution area (Potts 1986). The decreased survival of the chicks, attributed to a lowered amount of insects, has been suggested to be one of the main reasons for the worldwide reduction in partridge stocks (Potts 1986).

The diet of grey partridge chicks has been studied, for instance, in England (Ford et al. 1938, Green 1984, Potts 1986) and France (Serre & Birkan 1985, Birkan & Serre 1988), but not in Finland, where the worldwide distribution of grey partridge extends northernmost. Invertebrates have been shown to be important and necessary food items to chicks during the first post-hatching weeks (Ford et al. 1938, Green 1984, Potts 1986, Serre & Birkan 1985, Birkan & Serre 1988). The older chicks primarily prefer a plant diet (Ford et al. 1938).

The aim of this study was to investigate the grey partridge chicks' food composition in central Finland, paying special attention to the selection of food.

2. Material and methods

The study area is located in the municipality of Tyrnävä, Finland (64°47′N, 2540′E), in the centre of a ca. 20 km^2 research area in arable land. Basically the area is open-ditched and a small river runs through the research area.

Birds under investigation were caught with cages from their winter feeding places from Feb 15 to March 27, 1991, and they were fitted with radio transmitters (Biotrack, TW-2, 9 g or SR-2, 12 g). Altogether, five broods were selected for our study in June–July 1991. However, only three broods could be followed throughout the research period. One pair lost all the chicks within a couple of days after hatching, and one brood moved to a crop field where our access was denied by the landowner. The broods included in the study are hereafter called A, B and C. They were located in the morning, in the afternoon and in the evening as follows: A; 25th June–18th July, B; 6th–18th July and C; 14th–28th July. Based on evening tracking, the night roosting places were checked the following morning after the birds had moved away.

All the chicks' droppings were counted and collected from the night roosting places the following morning. The samples were stored in plastic tubes and frozen as soon as possible. Because the inspection of all collected droppings would have been an enormous task, four randomly selected chick droppings from every second night were analysed. The total number of droppings analysed was 36, 30 and 32 for the broods A, B and C, respectively. Before further study the droppings were stirred in water in a small Petri dish, and 70% alchohol and a drop of dilutant was added. After four hours' dissolving, the droppings were crushed under stereomicrosope viewing without sieving (cf. Green 1984, Moreby 1987) Remnants of prey items were satisfactorily observed in this way without the laborious sieving. A piece of millimetre paper was set under the Petri dish to give the scale for the invertebrate fragments.

Ground layer animals were collected in pitfall traps and with sweep net for reference material. One week before the estimated hatching time three pitfall traps at five metre intervals were dug into the ground in at least three different habitats available for each brood. Saturated NaCl solution with a drop of dilutant was used as a trapping liquid in the pitfalls. A lid was placed 1 cm above each trap. The trapping of invertebrates was carried out throughout the three-week period.

Based on brood locations for the previous day, the sweep net samples were collected in the area where the broods lived. One sample consisted of ten sweeps. The net diameter was 37 cm and the length of one sweep was 1.5 m, which makes the total netted area up to 5.5 m^2. The first netting was done during the hatching period and twice thereafter at a one-week interval. Total numbers of netting samples for broods were A 17, B 10 and C 13. These methods for collecting invertebrates were used just to get some idea of the possible invertebrate fauna available for the chicks.

The identification of the diet from the droppings was based on the most typical parts, which are easiest to recognise. Such fragments were total heads (Coleoptera, Hetereroptera, Homoptera), maxillae and other mouthparts (Phalangida, Araneae, Coleoptera, Hymenoptera, Lepidoptera larva), ovipositors (Homoptera, Hymenoptera), wings (Diptera, Hymenoptera, Coleoptera, Homoptera) and legs (Coleoptera, Diptera, Phalangiidae, Araneae, Homoptera) (see also Moreby 1987, Ralph et al. 1985). If some fragment was not immediately identified, a sketch was drawn of it and a correct taxon was determined later. Several fragments from all taxa were registered, but the number of individuals was estimated from the maximum number, mostly to the family level.

The volume proportion of plants and animals was estimated by three samples taken from every dropping dissolved and distributed evenly in Petri dish. This was done by eye using the same magnification all the time.

3. Results

3.1. Brood habitats, movements and survival of the chicks

Most of the radio bearings taken from brood A (61%) were located in set-asides, 32% in an oatfield and 7% in hayfield. Brood B stayed in barley fields during the whole study period (98% of the locations) and only once visited a hayfield. The radio bearings of Brood C were obtained from barley (54%), set-aside (32%), hay (10%), and oat fields (4%).

The mean (± S.E.) day travel distances (the distance between three successive locations) was 347 ± 44 m (range 90–610 m) for brood A, 422 ± 69 m (range 155–1060 m) for brood B, and 319 ± 46 m (range 140–680 m) for brood C during the study period. The movements of the three broods did not differ from each other (analysis of variance, F = 0.983, P = 0.41).

Survival of chicks during the study period was similar in broods A and B, in which 70% of the hatched chicks (n = 20 for both broods) were alive at the end of the study. The survival of the chicks in brood C (n = 15) could not be properly determined, since the brood was lost at the end of the study, after the radio-tagged hen was killed by a cat. However, based on the number of chick droppings in latest night roosting places (12), and on the knowledge that each chicks produced, on average, 1,5 droppings per night, the number of chicks surviving till the death of the hen was estimated to be eight. Thus, 53% of the hatched chicks in brood C would have survived till the end of the study.

3.2. The diet of the broods

The total number of food items identified and the average number of determined food items per a single dropping were fairly equal in broods B (449, x = 14.9) and C (535, x = 16.7), while they were much larger in brood A (1195, x = 33.2). The most abundantly eaten invertebrate taxa were Delphacidae, Chrysomelidae, Carabidae, Silphidae (larva, chiefly in brood B), other Coleoptera, Heteroptera, Phalangida, and Cyclorrapha (Table 1).

When all the droppings are surveyed together in a detrended correspondence analysis (DCA), different broods can be clearly separated into their own subgroups. Axis 1, which explained about 30% of the variation in the diet between the broods, separates brood C from broods A and B. Axis 2, which explaned about 25% of the variation in the diet of broods, separates broods A and B (Fig. 1.). The dietary overlap calculated by Morisita's measure (Morisita 1959, presented in Krebs 1989) was 0.56 between broods A and B, 0.59 between the broods A and C, and 0.45 between broods B and C.

3.3. Comparison with available food

Friedman's (1937) test, based on ranking the difference in use and availability of invertebrates for each brood (see Table 2), showed that chicks of different broods selected their food similary (χ^2 = 57.97, df = 25, P = 0.0002). The most preferred (highest mean ranking numbers) invertebrate taxa were Delphacidae and Coleoptera. The least preferred (lowest ranking numbers) food items belonged to the taxa Diptera and Araneae (Table 2). As can be seen from Figure 2, there was both plant and animal material in the droppings of brood A in equal amounts during the first week. During the second week the proportion of plants decreased to 5%, while that of animals increased to 95%. During the third week the proportion of animal food decreased sharply. In the diet of Broods B and C the proportion of invertebrates was 90% during the first week, despite the sixth day of brood C, when it temporarily decreased to 60%. At the end of the second week the proportion of animal food decreased in the diet of brood B, whereas it still made up over 80% of the diet of brood C.

4. Discussion

Our results concerning the proportion of animal food in the diet of grey partridge during the first weeks after hatching are mainly in agreement with earlier studies. According to Ford et al. (1938) and Potts (1986), the proportion of invertebrates is over 90% in the diet of newly-hatched partridge chicks, while after three weeks the proportion of plants increases up to 90% (Ford et al. 1938). It must, however, be emphasised that the study of Ford et

Table 1. Number of invertebrates in grey partridge chicks' droppings (=d) in different broods (A–C), in pitfall traps (pf) and in sweep-nettings (n). Pitfall and netting samples are from the habitat of the brood inquestion (see mat. & met).

Taxon	Ad	Bd	Cd	Apf	Bpf	Cpf	An	Bn	Cn
Lumbricidae				2		2			
Stylommatophora					3				
Limacidae			10						
Araneae	17	17	19	780	396	222	20	4	7
Phalangidae	37	2	57	434	130	108	14		1
Acarina			1	74	1	29	1		3
Collembola				1478	645	172	9		
Odonata	1								
Psocoptera							1	1	
Thysanoptera					2		30	111	173
Cercopidae			59				5	9	48
Cicadellidae	3	5	24	20	53	315	46	8	72
Delphacidae	448	51	70	9	15	12	145	9	10
Psylloidea	10					1	39	2	
Aphidoidea	35	14	20		1	2	17	20	41
Other Homoptera			1	1					
Heteroptera	35	19	49	7	1	1	1	23	45
Nabiidae	1				2		29		
Miridae	11		4		2	7	110	59	373
Saldidae	2		6	12	1	2			
Carabidae	57	35	25	98	20	16	9		
Scaritini	16	5	1						
Silphidae	2	1	2	1	5	29			
Silphidae (larva)	24	112	1	1	6				1
Staphylinidae	17	21	4	115	127	65	1	2	
Scarabaeidae		7	1		5	20			
Chrysomelidae	105	28	8	2		2	9		
Curculionidae	23	4	16	3	4	2	6	1	
Coleoptera (larva)	10	3	9	9	41	61	6		
Other Coleoptera	164	51	29	24	41	164	26	5	3
Strepsiptera									1
Tenthredinidae	10	2	6				1	1	1
Ichneumonoidea	22	10	37	49	74	53	58	17	22
Chalcidoidea	3	5	3	57	45	133	78	143	110
Prototrupoidea					57	68	93		
Formicoidea	4		6	7		8			
Other Hymenoptera	31	11	2	4	10		8	2	10
Neuroptera						1	1		1
Panorpidae						1			
Nematocera	8		3	7	3	10	12		4
Nematocera (larva)			3			1		7	
Tipulidae	28	7	7	3	8	3	6		2
Culicidae							106	391	
Chironomidae	2			4	3	7	407	223	519
Sciaridae	2	1	1	37	402	127	14	23	58
Scatopsidae							147	10	6
Cecidomyidae				6	28	28	10	4	6
Empididae	11	6	9	13	3	4	242	280	67
Dolichopodidae				9	29	45	83	67	52
Cyclorrhapha	37	27	32	32	34	64	147	200	413
Lonchopteridae		1		3			15	10	14
Phoridae				36	18	22	10	8	3
Ephydridae		1		6	4	25	144	57	145
Sphaeroceridae		1		226	57	46		5	6
Anthomyidae					7	10	29	19	30
Muscidae				11	13	33	196	38	28
Other Diptera	5				1	2	3		2
Siphonaptera				1	1				
Trichoptera	5		1	1	3			6	
Lepidoptera larva	9	2	19	11	1	2	19	2	2
Other Lepidoptera					2		8	3	5

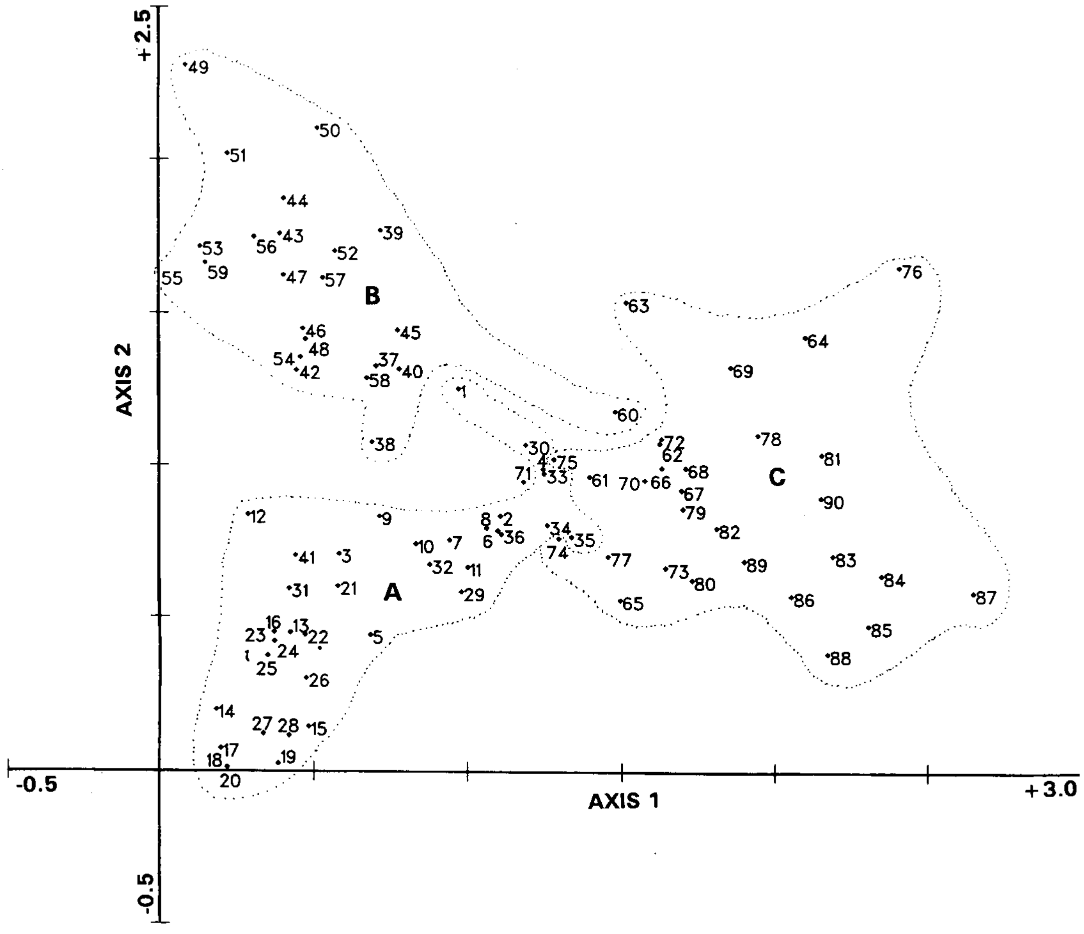

Fig. 1. DCA biplot of the total pellet material of the three grey partridge broods: A (droppings nos. 1–36), B (nos. 37–60) and C (nos. 61–90). Eigenvalues: axis 1 = 0.379, axis 2= 0.266.

al. (1938) was based on crop samples, while we have analysed droppings. Based on dropping analysis, Green (1984) also found that animal food was dominant in the diet of chicks during the first week, decreasing steadily after that. Our results confirm that invertebrates are chicks' main food items during the first two weeks, but some exceptions to this general rule were also observed. The proportion of animal food was clearly lower in the diet of brood A than in the diet of the other two broods during the first week of life. This is attributed to the earlier date of hatching of brood A, when the weather was still cool and rainy (Finnish Meteorol. Inst. 1992). It is also noteworthy that the proportion of animal food in the diet of brood B decreased sharply as early as the second week. This was more probably due to weather conditions (heavy rain) during that particular day (17th July, Finnish Meteorol. Inst. 1992) than to a real change of diet towards vegetative food, since a similar decrease in the proportion of invertebrate food was also observed in the diets of broods A and C on the same day (Fig. 2).

The importance of invertebrates as chick food is also documented with tetraonids. Capercaillie *Tetrao urogallus* and the black grouse *Tetrao tetrix* chicks use invertebrates almost exclusively as a food source during the first post-hatching weeks, and even later on in the autumn insects and spiders make up a remarkable proportion of their diet (Rajala 1959, Helminen & Viramo 1962). The protein content of the invertebrate food stimulates rapid muscle growth, which is important for the development of flying ability (Dahlgren 1987, Potts 1986).

A close relative to the partridge, the red-legged partridge *Alectoris rufa* is already able to use seeds at the age of two days, whereas grey partridge chicks are not able to break seeds earlier than at the age of ten days. The proportion of plants is thus much greater in the diet of the red-legged partridge than in the grey partridge during the post-hatching period (Green et al. 1986).

The clear evidence of food selection by chicks despite the small sample size is quite astonishing. The chicks of all broods studied seemed to prefer taxa of Delphacidae, Coleoptera and Aphidoidea, whereas they consumed less taxa of Araneae and Diptera than expected on the basis of their abundance. Our results are principally in agreement with Green (1984), who found that grey partridge chicks consumed more Aphididae, Heteroptera and Coleoptera, and less Diptera than could be assumed on the basis of their availability. Similary, Ford et al. (1938) found that the invertebrates most abundantly eaten by grey partridge chicks were larvae of weevils and Lepidoptera. Also, our data mainly support that given by Potts and Aebisher (1991), who found that the most important insect taxa for the survival of grey partridge chicks in Sussex were Carabidae, Symphyta and Lepidoptera larvas, Chrysomelidae, Curculionidae, Heteroptera, Cicadellidae and Amphididae. However, the importance of caterpillars (Symphyta and Lepidoptera) for grey partridge chicks could not be clearly documented in our study. Although selected by the chicks, the proportion of the caterpillars remained low in the diet of the chicks. One may ask whether

Table 2. Percentage distribution of prey taxa in droppings (D) of grey partridge broods (A–C) and availability (Av.) of invertebrates in combined catch of pitfall traps and sweep nettings. Ranking number (R) based on the difference between use and availability is shown.

	A			B			C					Mean
Taxa	D	Av.	R	D	Av.	R	D	Av.	R	ABC	Tot. Av.	Rank
Aranea	1.4	18.6	2	3.8	13.5	2	3.6	6.1	5	2.4	12.9	3.0
Phalangiidae	3.1	10.4	4	0.4	4.4	6	10.7	2.9	24	4.4	6.2	11.3
Cercopidae	0.0	0.1	10	0.0	0.3	10	11.1	1.3	25	2.7	0.6	15.3
Cicadellidae	0.3	1.5	7	1.1	2.1	7	4.5	10.3	4	1.5	4.7	6.2
Delphacidae	37.5	3.6	26	11.4	0.8	24	13.1	0.6	26	26.1	1.8	25.3
Psylloidea	0.8	0.9	10	0.0	0.1	13	0.0	0.0	11	0.5	0.4	11.5
Aphidoidea	2.9	0.4	22	3.1	0.7	21	3.8	1.1	18	3.2	0.7	20.3
Heteroptera	4.1	3.7	14	4.2	3.0	19	11.1	11.3	8	5.8	6.1	14.0
Carabidae	5.4	2.0	23	7.6	0.6	23	3.9	0.4	21	5.5	1.1	22.5
Silphidae larva	2.0	0.0	20	24.9	0.2	26	0.2	0.0	12	6.3	0.1	19.5
Staphylinidae	1.3	2.5	7	4.7	4.4	15	0.6	1.7	7	1.8	2.7	10.0
Chrysomelidae	8.5	0.3	24	6.2	0.0	22	1.5	0.1	17	6.3	0.1	21.0
Curculionidae	1.9	0.2	19	0.9	0.2	18	2.8	0.1	19	1.9	0.1	18.7
Coleoptera larva	0.8	0.0	16	0.7	1.4	9	1.7	1.7	10	1	1.0	11.8
Other Coleoptera	15.1	2.1	25	14.5	2.0	25	7.3	4.1	20	13.1	2.8	23.3
Tenthredinidae	0.8	0.0	16	0.4	0.0	17	1.1	0.0	15	0.8	0.0	16.2
Ichneumonidae	1.8	2.5	9	2.2	3.1	8	6.9	2.0	23	3.2	2.5	13.3
Chalcidoidea	0.3	3.1	6	1.1	6.4	5	0.6	6.4	3	0.5	5.1	4.7
Formicoidea	0.3	0.2	12	0.0	0.0	14	1.1	0.2	14	0.5	0.1	13.5
Other Hymenoptera	2.6	1.5	18	2.4	2.6	12	0.4	2.7	6	2	2.2	12.0
Tipulidae	2.3	0.2	21	1.6	0.3	19	1.3	0.2	16	1.9	0.2	18.8
Empididae	0.9	5.9	5	1.3	9.6	4	1.7	1.9	9	1.2	6.6	6.0
Cyclorrapha	3.1	19.8	3	6.7	15.9	3	6.0	21.8	2	4.5	19.4	2.7
Other Diptera	1.4	19.8	1	0.2	28.2	1	1.3	23.0	1	1.1	23.1	1.0
Trichoptera	0.4	0.0	14	0.0	0.3	10	0.2	0.0	12	0.3	0.1	12.5
Lepidoptera larva	0.8	0.6	12	0.4	0.1	15	3.6	0.1	21	1.4	0.3	16.5

caterpillars are able to be properly detected in the faeces, since Green (1984) also found the proportion of them to be low in the droppings of grey partridge chicks. However, we are convinced that the larvae of Lepidoptera were well distinguishable, since their chitinated mandibles are well recognizable in droppings.

Serre and Birkan (1985) documented that ants and their pupae were the most important food items of grey partridge chicks in France. Also, Potts (1986) observed that ant pupae are an important food of chicks aged between two and six weeks. Only a few ants were discovered from the droppings in our study, suggesting their minor importance for grey partridge chicks in our study area. However, it must be noticed that ant pupae may not be detected efficiently from droppings, and their importance to chicks may thus be underestimated in our study. The same can be true for Collembolas, which can be found abundantly in the crops of chicks (Ford et al. 1938), but cannot be detected from droppings (Green 1984).

The importance of taxon Delphacidae as prey item to the grey partridge chicks was a surprising result, since this has not been reported in earlier studies. The chicks' preference for Delphacidae in our data is unquestionable if we consider the small abundance of this taxon within each habitat of the broods (Table 2). However, the real availability of different invertebrates probably depends on the structure of the habitat used by the broods. Thus, the fact that the brood habitats in our study included set-asides and ditch banks, whereas the main brood-rearing habitat in Central Europe is monocultural cereal (Green 1984), may explain the discrepancies between our results and results obtained elsewhere.

One striking prey group which appeared in our study, especially in the diet of brood B, was larvae of Silphidae. Although most of the Silphidae species are carrion feeders, adult Silphidae found in our pitfall traps were either *Phosphuga atra* a predator of snails, or *Blitophaga opaca* a herbivore (see Freude et al. 1971). However, the existence of a carrion in the habitat of brood B cannot be excluded from explaining the large numbers of Silphidae larvae in the diet, since these could not be determined to a species level on the basis of mandibles found in droppings.

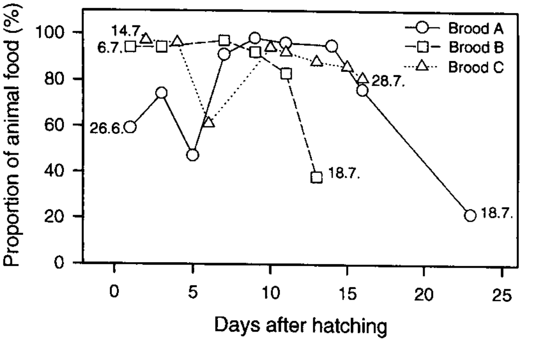

Fig. 2. Proportions of animal food in the diet of grey partridge chicks in central Finland. First and last date of study period for each brood is shown beside the corresponding symbol.

The real availability of the invertebrate taxa for the grey partridges is difficult to verify, since little is known of how efficiently chicks can find and catch different prey items in various habitats. For instance, as suggested by Green (1984), Dipteras may be too fast-moving for the chicks to catch. On the other hand, the minor use of spiders when compared to their availability may reflect real avoidance of them by chicks.

Although chicks have a tendency to select their food items uniformly, the overlap of the diet between the broods was not greater than 0.45-0.59. The spatial differences in abundance and composition of invertebrate fauna is probably the reason why each brood could be separated into its own group in DCA-analysis. Brood A primarily foraged in a set-aside field, whereas brood B lived almoust exclusively in a barley field. The habitat of brood C was most diverse including barley, set-aside, hay and oat fields. The key prey groups which separated brood C from broods A and B on the axis 1 in DCA-analysis were Cercopidae and Cicadellidae. Correspondingly, Delphacidae, Silphidae larva and Chrysomelidae were the key groups which separated broods A and B on the axis 2 (Fig. 1).

Our results of the diet of grey partridge chicks in northern ranges mainly support the data obtained from other central distribution areas of this species. However, some divergences of our results compared to existing data indicate the adaptability of grey partridge to the climate and agricultural structure characteristic for a northern country.

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Selostus: **Peltopyyn poikasten ravinnon koostumus Keski-Suomessa**

Tutkimme kolmen peltopyypoikueen ravinnon koostumusta ja ravinnonvalintaa vuonna 1991 Tyrnävällä, n. 20 km Oulusta kaakkoon. Ulosteista tehtyjen määritysten perusteella peltopyyn poikaset söivät kolmen ensimmäisen elinviikon aikana pääasiassa selkärangattomia, joiden lajivalikoima ravinnossa oli hyvin laaja. Lukumääräisesti eniten poikaset söivät kovakuoriaisia (Coleoptera) ja viljakaskaita (Delphacidae).

Kun tarjoalla olevien selkärangattomien määrä otettiin huomioon, näyttivät kaikki poikueet, erilaisista poikueympäristöistä huolimatta, valitsevan ravintonsa hyvin samankaltaisesti. Poikasten suosittuja ravintokohteita olivat erityisesti viljakaskaat (Delphacidae), lehtikuoriaiset (Chrysomelidae), muut kovakuoriaiset (Coleoptera) ja kirvat (Aphidoidea). Sen sijaan poikaset söivät tarjolla olevista kaksisiipisistä (Diptera) ja hämähäkkeistä (Araneae) vain suhteellisen vähän.

Tyrnäväläisten peltopyyn poikasten ravinnonkoostumus on pääosin samanlainen kuin englantilaisten ja ranskalaisten peltopyiden poikasten, mutta ravinnonkoostumuksessa oli myös joitain eroja, jotka kuvastavat peltopyiden sopeutumista levinneisyysalueensa pohjoisissa osissa vallitseviin olosuhteisiin.

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